Pioneer Venus & Galileo Probe Development: Comparison/Assessment

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Program Characteristics

Pioneer Venus

- Program Manager at NASA HQ - no change during program
- Pioneer Venus Project Office at Ames
  - Experienced Project Manager and staff
- Prime System Contractor - Hughes Aircraft Company - GE Reentry Systems Major Subcontractor
  - Experienced spacecraft staff
  - Staff scientist through PDR
- Mission Requirements established and negotiated at beginning of project - no significant changes

Galileo

- Program Manager at NASA HQ - multiple managers
- Galileo Project Office at JPL
  - Experienced Project Manager (several) and staff
- Galileo Probe Project Office at Ames
  - Experienced staff from Pioneer Venus
  - Staff scientist through PDR
- Prime System Contractor - Hughes Aircraft Company - GE Reentry Systems Major Subcontractor
  - Experienced spacecraft staff

Program Characteristics - Cont'd

- Development Cycle 4 Years
  - Launch on schedule as established at beginning of project
  - No major program changes
- Project Completed within initial budget
- Very Successful Flight - with minor anomalies

- Multiple and Major Galileo Spacecraft Mission Requirements Changes
- Development Cycle
  - Initially 4 years stretched to 10 years with numerous iterations
- Major overruns due to technical difficulties and mission changes

- Very Successful Flight - with minor anomalies

Mission Requirements/Characteristics

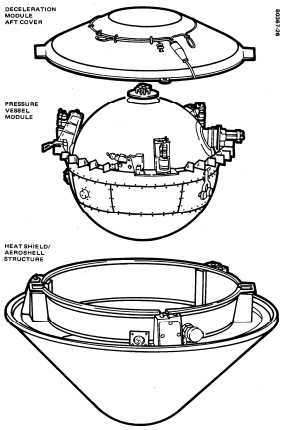
Pioneer Venus

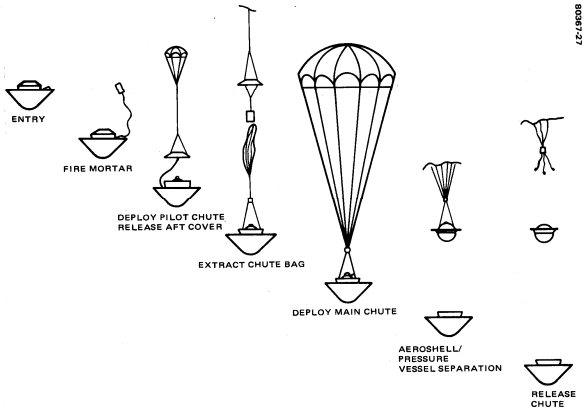
- Large Probe & Three Small Probes: carried on dedicated Bus Spacecraft
- Launch to Separation: 125 Days
- Separation to Entry: 23 Days
- RF Link: Direct to Earth (DSN)
- Entry Conditions
  - Velocity: 42,000 Km/Hr
  - Maximum Stagnation Heating: 4.7 Kw/ cm^2
  - Max Deceleration: 280 g's
- Descent Environment Requirements/Conditions
  - Pressure: 0 - 92 Bars
  - Temperatures: 190 to 740 Deg K
  - Descent Time: 54 Min

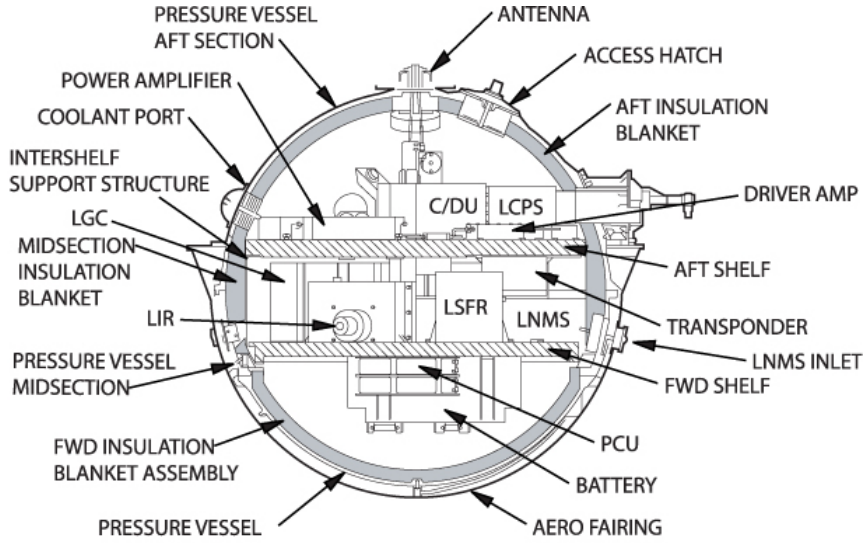
Galileo

- Single Probe: carried on Galileo Spacecraft
- Launch to Separation: 1729 Days
- Separation to Entry: 147 Days
- RF Link: To Galileo Spacecraft
- Entry Conditions
  - Velocity: 158,400 Km/Hr
  - Maximum Stagnation Heating: 17 Kw/cm^2
  - Max Deceleration: 250 g's
- Descent Environment Requirements/Conditions
  - Pressure: 0 - 15 Bars Req. (25 Actual in flight)
  - Temperatures: 177 to 442 Deg K
  - Descent Time: 75 Min

Pioneer Venus Large Probe Overview

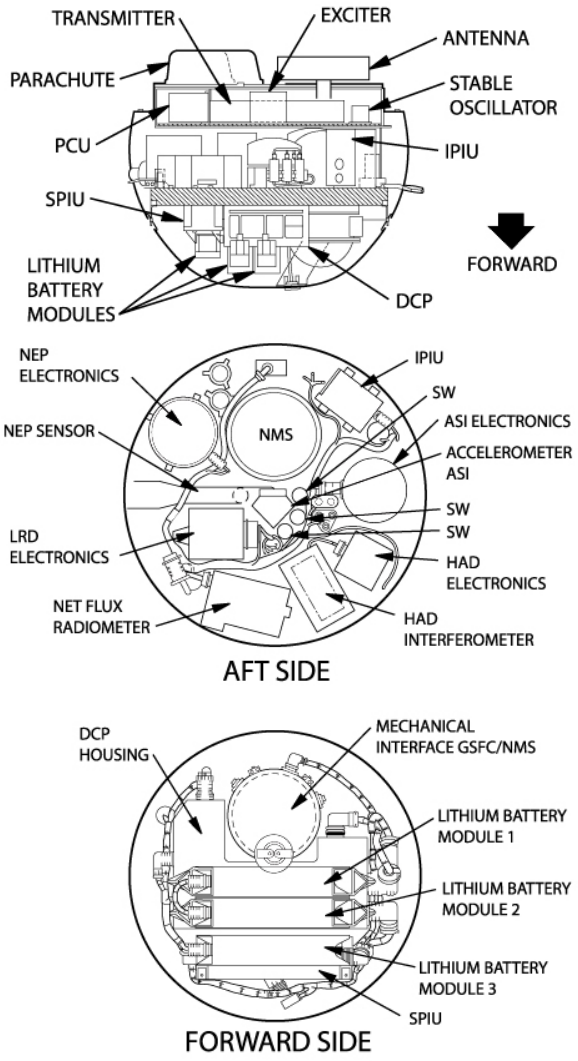






- Mass 315 kg
- Diameter
  - Aeroshell 142 cm
  - Pressure vessel 73 cm
- Battery 19 cell AgZn, 40 A-h
  Data rate 128/256 bps
- Pressure Design
  - 10 vessel penetrations (3 science)
  - 9 windows (8 sapphire, 1 diamond)
- 7 science inst, 29 kg total, 106 W

Galileo Probe Overview



- **Probe**
  - **– Mass 330 kg**
  - **– Diameter 125 cm**
- **Battery 13 cell $LiSO_2$, 22 A-h**
  Data rate 128 bps
- **Science Accommodation**
  - **6 vessel penetrations**
  - **1 deployment**
- **7 science inst, 30 kg total, 26 W**

Design

Pioneer Venus

- 45 Deg Half-Angle Cone
- Maximum Diameter - 142 Cm
- Mass - 303 Kg
  - 109 Kg - Deceleration Module
    - 32.5 Kg Heatshield
    - 76.5 Kg Structure, parachute, separation, harness
  - 132 Kg - Descent Module structure and harness
  - 26.5 Kg - Engineering S/S
  - 35.5 Kg - Science Instruments
- Limited redundancy

Galileo

- 45 Deg Half-Angle Cone
- Maximum Diameter - 125 Cm
- Mass 330
  - 219 Kg - Deceleration Module
    - 170. Kg Heatshield
    - 49.0 - Kg Structure, parachute, separation, harness
  - 43.2 Kg - Descent Module structure and harness
  - 42.8 Kg - Engineering S/S
  - 25 Kg - Science Instruments
- No Single Point Failures

TEST PROGRAM

- **Protoflight Approach - Same for both PV & Galileo**
- **Major Development Program**
  - **Structure, thermal, windows (PV), seals (PV), module separation, parachute drop tests, aerodynamics**
- **Probe Flight Vehicle**
  - **Unit Level: Qual, flight level tests**
  - **Probe System Level: Prototype level tests: Vibration, Deceleration, Descent Pressure - Temperature**
- **Probes with Spacecraft**
  - **Prototype Tests: Acoustic, solar- thermal vac**

Major Challenges & Test Failures

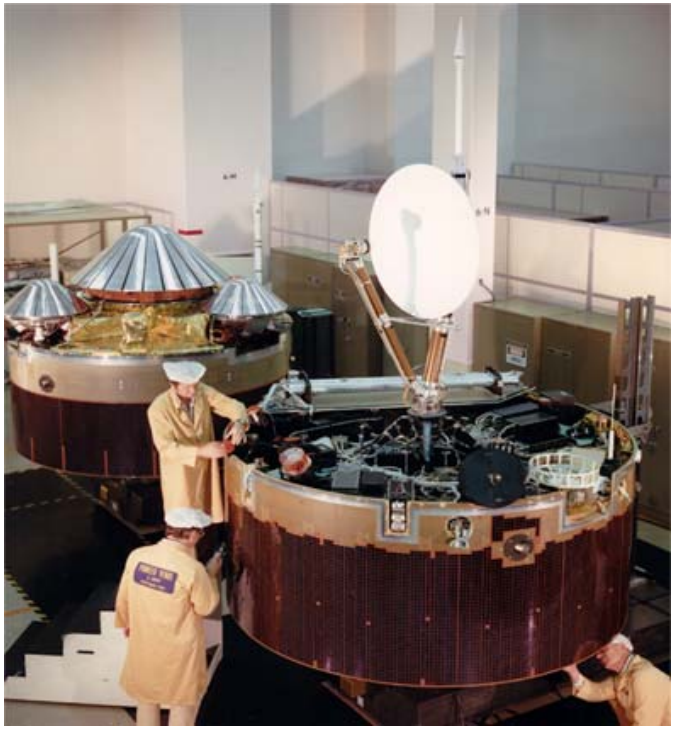
Pioneer Venus

- Parachute Canopy Design
  - Initial design failed structurally - changed design
- Pressure Vessel Seal Design
- Window/Window Heater & Seal design
  - Sapphire -
  - Diamond
- Battery Cell failure in Thermal Solar-Vac Test

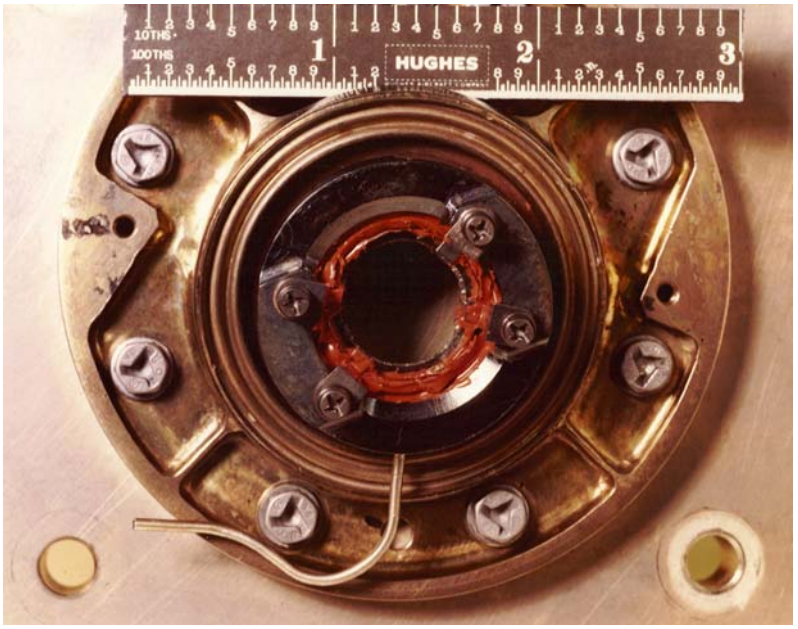
Galileo

- Heatshield Design
  - Ablation products enhancement
  - Spallation
- Parachute Opening Problem
- Eliminating single point failures
- Single Event Upsets
- Mission duration
  - Batteries
  - Pyros

Pioneer Venus Bus Spacecraft



IR Instrument Window Design



SUMARY/CONCLUSIONS

- **Both missions were highly successful - met mission requirements and returned good science**
- **Bernie is right: “Test what you fly and fly what you test.”**
- **Analyze flight-data for anomalies - find out what caused them**
- **Space projects are hard work**
  - **It takes a dedicated team**
  - **There are difficult, perplexing, unexpected and discouraging problems**

MISSION SUCCESS REMOVES ALL OF THE PAIN AND AGONY IT TOOK TO GET THERE!